PROCEDURES FOR DEVELOPMENT RATE MEASUREMENT (DRM)
VERSION 3: DEE 09/2002

Microlithography Materials and Processes Laboratory (EMCR676 / 751)
Microelectronic Engineering Department
Rochester Institute of Technology

1.0 Materials Required

1.1 Bare Silicon Wafer

2.0 Preparation of Wafer

2.1 Dehydration Bake - 2 minutes, 250 °C on contact hot plate*

2.2 If you are coating HMDS onto wafer:
- (1) Coat HMDS onto wafer
- (2) HMDS bake - 90 sec., 90°C on contact hot plate*

2.3 If you are coating a Bottom Anti-Reflective Coating onto wafer:
- (1) Coat BARC as per standard processes
- (2) Bake BARC as per standard processes
- (3) Wipe down spin coater (BARC will eat away at plastic of coater)
- (4) Note – measure BARC thickness using Nanospec (see Sec. 3) under program for polyimides on Si and reflectance of BARC under Reflectance program. You will not be able to measure the resist thickness later. In order to determine the approximate thickness, coat a reference wafer (no BARC) under the same conditions and measure its thickness.

2.4 Coat resist onto wafer - spin program dependent on required thickness (see Baseline Process Conditions for resist)

2.5 Softbake (see Baseline Process Conditions) on contact hot plate*

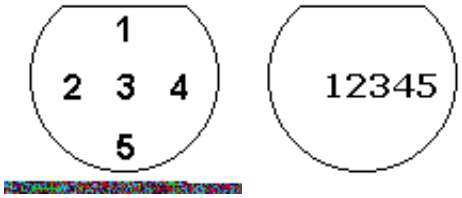
*Always allow wafer to cool before coating

SSI Track Coating: HMDS, photoresist coating, baking parameters are available using the SSI track. Refer to the SSI manual for detail instructions.

3.0 Measure Resist Thickness on Wafer, Using Nanospec

3.1 Hold down calibrate button until instrument responds
3.2 *Print Film Menu?* Respond “NO”
3.3 *Enter Film Type*. Respond “10” - this is for positive resist on Si
3.4 *Enter Obj Lens*. Respond “1”
3.5 *New Ref Wafer?* Respond “YES”
3.6 Focus on Reference Wafer, then push measure
3.7 *Enter sample #* Respond with “Enter”

3.8 Measure thickness on wafer in five regions by focusing on wafer and pushing “Measure”. The five regions are as follows: The left diagram maps the entire wafer; the right diagram concentrates on the radial thickness the DRM views.



3.9 If thickness is not within desired range, coat another wafer, changing spin program accordingly.

4.0 Exposure on the Canon FPA-2000 i1 Stepper

4.1 Load a blank reticle into reticle cassette and insert into first slot of the machine. Be sure that clip is still forward in locked position. Green light next to position 1 should remain on.

4.2 Load wafer onto wafer carrier, face up. Load carrier into position. Make sure there is a receiver carrier in corresponding receiver position. Press “Start/Reset” button next to carrier.

4.3 Screen should read **SEQ NO. 001E**. This means it is okay to use.

4.4 Enter **AUX FEC**

4.5 Use **NEXT** and **PREV** buttons to scroll through program, in order to insure the proper exposure parameters.

4.6 On the second page input: **Program: DRM**
Choice of shot, column, row Choose **Column**
Initial E = 0 mJ/cm2
Increment = 25 mJ/cm2
Or you may desire different parameters and so input.

4.7 Once the program is as desired:
Job Load
(F3) Parameter Save (Pram Save)
(F4) Parameter Load (Pram Load)
Load the wafer **onto** the cassette onto the sender.
(F1) Go
Press the Start/Reset button near the sender. Note: After the (F1) Go is depressed.

4.8 If you receive this error:
Manual Operation Mode at MA before AA
Press **CONTINUE** button just below screen. This error is not important.

4.9 When exposure is done, remove wafer from receiver and perform a Post-Exposure Bake (see Baseline Process Conditions) using a contact hot plate.

4.10 Always remove reticle when you are done with the Stepper (see below for command)

4.11 Other commands you should know:

QRS Quick Restart - used if wafer is stuck or program is not working properly
RCH Load reticle
RRL This retrieves the reticle. This should be performed when you are done with stepper
LD Load wafer onto stage (used mostly in ABC Parameter determination)
RLLD Retrieves wafer
** For other commands, the manual is always present near the instrument.

5.0 Development Rate Measurement

5.1 Make sure the drainer is set to DRAIN, and set to off. Then, place the appropriate developer (see Baseline Process Conditions) in solution compartment. Let stabilize for at least 10 minutes. Measure temperature with thermometer.

5.2 Turn on computer and Optical Measuring Instrument

NOTE: Reboot the computer and Switch off then on the DRM after each wafer of collected data.

5.3 **Select DRM Test and run the DRM test.**
To Check GAIN:
When readout is **46**, insert blank wafer.
To check gain, remove wafer while instrument is running. Readout should show a pronounced effect (gray pattern) if it is working properly. If Gain is okay, remove wafer and place in Pyrex dish filled with DI water.

5.4 Enter **DREAMS** software. **Hit Proceed.**

5.5 **Define**: Fill in resist name, operator name, and run # (i.e. UltraiNFL1 means: Resist = Ultrai120, operator is Neil F. Langille, this is the first time this resist has been run). Another convention used is to identify the resist/developer with or without BARC (i.e. 825/934.B is the Olin 825 resist with OPD 934 developer with a BARC layer on bare SI substrate) or other appropriate wafer identification.

5.6 Create New Wafer Set Up or Load Response File

There are two choices: to create a New Wafer Set up or Load Response File.
When creating New File - step through each entry window and input the appropriate information.
Critical ones are: Source wavelength, sampling time, scan rate and number of scans
(with this there is an option for default values), resist type, index of refraction, AFT thickness, exposure wavelength, Template (**Need this), and developer type.

Load a file with identical exposure parameters (i.e. same initial exposure dose, same increments, etc. An example is “Ult1hr”). Then fill in average thickness of coating, resist type, exposure parameters, and number of scans requested (determines the length of exposure - cannot exceed 1500 total scans)). Follow the menu and choose the appropriate template.

5.7 Check solution temperature manually with a thermometer enter in proper box.

5.8 Load wafer onto holder. The flat goes toward the bottom of the holder. Use hole in center of holder to center the wafer.

5.9 From main menu, hit **COLLECT** button. The screen will show pixels used for collecting data. The pixels shown can be chosen. Enter **PROCEED**. When Optical Measuring Instrument (OMI) reads "46", load wafer promptly. Data collection for each pixel will be shown on the computer screen on a real time basis for the pixels chosen. All 256 pixels are gathering data on a real time basis.

5.10 When run is over, promptly remove wafer and place into Pyrex dish or beaker filled with DI water.

5.11 To clean the developer bath, turn selector to DRAIN. Then turn on the pump. When solution is gone, rinse with DI water and pump again. Rinse a total of three times. Wipe dry.

NOTE: Reboot the computer and Switch off then on the DRM after each wafer of collected data.

6.0 DRM Data Management Step 1 - DREAMS Software

6.1 Press **Reduce** Button

6.2 Divide the spectrum into the appropriate number of distinct zones of exposure doses (i.e. 15 distinct zones). Partitioning the zones is accomplished in the following manner:

1) Click on the spectrum just above the pre-determined Zone 1. Then, click at the very end of the last pre-determined zone. Then press **Exclude**.
2) Count up the different partitions and get a good mental idea of where each zone starts and ends. It is easiest to count from Zone 15 at the bottom of the screen and work your way up to Zone 1. Now you are ready to define the zones. (Most exposed to the least exposed).
3) Start with Zone 1
4) Click on the upper limit of the Zone
5) Click on the lower limit of the Zone
6) Go to Zone Input and input the correct number
7) Go to Exposure Energy Input and put in the correct exposure dose (mJ/cm2).
8) Click **Include**
9) Repeat with all 15 Zone.
10) When done, press **Reduce,** then **Exit**

6.3 Press **Analyze** button. Then press **Set Extremes** button. Extremes are set in the following manner:

1) First, the computer will scroll through all 15 zones.
2) When this is done, press Review Zone, with Zone 1 selected in the box.
3) The computer automatically selects what it believes are the starting and finishing points, along with all minima and maxima of the plot. Start and End points are shown as white X's. Maxima are red X's and Minima are blue X's.
4) Define all Minima and Maxima, along with the start and end point points by clicking on the appropriate point on the spectrum, and pressing SET MINIMUM or SET MAXIMUM button.
5) Define Start Point and End Point by clicking on the appropriate point on the spectrum and pressing Set Start or Set End button. The end should be defined as the point where the plot begins to straighten out, after the last local maximum or minimum. If the resist has not cleared in this particular zone (i.e. the sine wave pattern appears cut off at the end of the screen), set the end point at the extreme right of the plot.

6) When all maxima, minima, and end points are defined, press Review OK button. Note: you must be inside the operable graphic area between start and finish to set the maxima and minima.
7) Press Review Zone button. The computer will automatically scroll to the next zone. In order to review a particular zone, press Review OK, fill in the zone number in the box, then press Review Zone.

6.4 In **Analyze,** after the extremes are set, go to **Eo.**

1) Start x = 0.05, End x = Total data collection time, Start y = 0.05 and end y = 500 for example. Update button, if OK then depress the OK button. Record the **Eo** points in your lab notebook.
2) In **Analyze**, go to **Ei**. Repeat the same settings as in **Eo**.
3) Next is the **Contrast Points**. Start x = 0.05 and end with the total collection time. Start y = 0.05 and end at 1.1 typically. The percentage range is typically the ASTM standard of 10% to 70%. Record the Contrast points in your lab notebook

6.5 Press **Plot,** and plot Thickness vs. Time, then **Proceed**.

6.6 If Plot is okay, press **Export**. Save **Dissolution Rate vs. Thickness** as .txt file onto hard drive, under the same naming conventions used to define the DRM file.

6.7 There are nine selections for Plotting. Choose the plot of interest. Plot the appropriate selection.

6.8 To obtain printouts of any active screen in windows (i.e. of interest such as Reduce Data & Wafer set-up). Open the window. Hit ALT and Print Screen. Open Microsoft Paint. Edit Paste. Select the area you wish to copy into Power Point. Edit copy. Go to Power Point. Edit Paste. Resize and position as necessary. Print. (Note: save as 16 colors to facilitate copy/paste).

7.0 DRM Data Management Step 2 - Conversion of data into ProDRM-friendly format

7.1 The purpose of this step is to enable the ProDRM software to read our data. The format of the data is very specific (see User's Manual, page **Appendix A-4**). The conversion is accomplished using Excel.

7.2 The first step in accomplishing this conversion is opening this file in Excel. Upon opening, you will be asked if the file is Delimited or Fixed Width. It is Delimited. Press NEXT

7.3 Next choose Tab and Commas as the two delimiters used in this file. Press FINISH.

7.4 The data is divided into two groups: those with the Thickness heading and those with the Normalized Thickness heading. Delete those with the Normalized Thickness heading.

7.5 Enter the following into the first column of the sheet {explanations are in these paranthesis}

```
[Version]
1                   {this is always 1}
[Parameters]
0                   {this is always 0}
1                   {this is always 1}
8                   {this corresponds to the maximum number of measurements
[Data]              for any one zone. In this example, all zones have 8 or less
                    measurements}
```

7.5 The data headings have the following pattern:

```
$$$$            {this separates the data for each Zone}
10              {this is the exposure level for the Zone.  10=Zone 1, 35=Zone 2, etc.}
```

7.6 The data is already in the following format:

Resist Thickness (µm) Rate (µm/sec)

The data must be converted to the following format:

Thickness into Resist (nm) Rate (nm/sec)

The conversion of the first column is accomplished using the following formula:
Thickness into Resist (nm) = [(initial resist thickness (Å))/10] - [(Resist Thickness (µm))*1000]

The conversion of the second column is accomplished using the following formula:
Rate (nm/sec) = Rate (µm/sec)*1000

7.7 Enter all data for the particular zone into the cells under the exposure level value.

7.8 Enter:

```
$$$$
35          {enter correct exposure value}
```

Then enter data for zone in appropriate format

7.8 If there are less than the maximum number of data points for a zone, enter the initial resist thickness (in nm) into column 1, and 0 into column 2.

7.9 Yes, this sounds confusing. Here is an example that may straighten things out.

Initial zone thickness = 8000 Å
Exposure parameters: initial exposure = 10 mJ/cm^2, 2nd = 35 mJ/cm^2, 3rd = 60 mJ/cm^2

This what your data file will look like in Excel:

Wafer ID:	S955XLX-1	
Wafer Defined on:	8/07/1998	13:33:02
Data Collected on:	8/07/1998	13:36:15

Dissolution Rate vs Thickness

Zone 2		Zone 3		Zone 4	
Thickness	Rate (um/sec)	Thickness	Rate (um/sec)	Thickness	Rate (um/sec)
0.229257	5.34E-05	0.55582	0.000161	0.723476	0.00165
0.144695	8.06E-05	0.459357	0.000181	0.627012	0.00265
0.048232	9.42E-05			0.530549	0.002192

This is what the converted file will look like:

```
[Version]
          1
[Parameters]
          0
          1
          3
[Data]
$$$$
         35
   570.743   5.34E-02
   655.305   8.06E-02
   751.768   9.42E-02
$$$$
         60
    244.18       0.161
   340.643       0.181
       800           0
$$$$
         85
    76.524        1.65
   172.988        2.65
   269.451       2.192
```

Note that the maximum # measurements is 3.
Note the blank data set in Zone 3 data.
Note that the first exposure is 35, corresponding to Zone 2.
Note the conversion of the actual data values and their corresponding units.

7.10 Save this file as a text file (.txt)

8.0 DRM Data Management Step 3 - ProDRM

8.1 Copy the text file into the c:/ProDRM/input folder of the computer.

8.2 Open ProDRM

8.3 Click on File/Load files

8.4 Select the appropriate file.